State of California
AIR RESOURCES BOARD

Small Off-Road Engine Evaporative Emission System Components
Executive Order Q-13-010
DSM Engineering Plastics
Innovative Products

WHEREAS, Pursuant to California Health and Safety Code, sections 39600, 39601, and 43013, the California Air Resources Board (ARB) has established a certification process for evaporative emission system components designed to control gasoline emissions from small off-road engines, as described in California Code of Regulations, title 13, section 2767.1;

WHEREAS, Pursuant to California Health and Safety Code, section 43013, ARB has established criteria and test procedures for determining the compliance of evaporative emission system components with the design requirements in Cal. Code Regs., title 13, section 2754;

WHEREAS, Pursuant to Cal. Code Regs., title 13, section 2767.1, ARB Executive Officer may issue an executive order (EO) if he determines that the small off-road engine evaporative emission system component or innovative product conforms to the applicable performance requirements set forth in Cal. Code Regs., title 13, section 2754 and 2755;

WHEREAS, Pursuant to California Health and Safety Code, sections 39515 and 39516, ARB Executive Officer issued EO G-05-008 delegating to the Chief of ARB Monitoring and Laboratory Division (MLD) the authority to certify small off-road engine evaporative system components and innovative products; and

WHEREAS, On January 18, 2013, DSM Engineering Plastics submitted an application for certification as an innovative product under Cal. Code Regs., title 13, section 2767(c) for model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material for injection molded fuel tanks.

NOW, THEREFORE, I, Michael T. Benjamin, Chief of MLD, find that fuel tanks produced using DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material and following the process and material specifications set out in Attachment A constitute innovative fuel tanks pursuant to Cal. Code Regs., title 13, section 2767(c). Fuel tanks produced following DSM Engineering Plastics process and material specifications are hereby deemed equivalent to those tanks listed in Cal. Code Regs., title 13, section 2752(a)(5). This finding is based on DSM Engineering Plastics demonstration that such fuel tanks have a permeation rate substantially lower than 1.5 grams per square meter per day set forth in Cal. Code Regs., title 13, section 2754, when tested at a constant temperature of 40° C pursuant to alternative test procedure ATP-10-001 using an approved test fuel of CE10 certification fuel.

IT IS ORDERED AND RESOLVED that no tank permeation data is required to be submitted in the certification process for equipment using the DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks.

IT IS ORDERED AND RESOLVED that all fuel tanks made from DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material with minimum barrier and nominal wall thicknesses equal to or greater than the value listed in Table 1 incorporated herein, are certified for use in small off-road equipment.

Table 1
Specifications for DSM Engineering Plastics Model Akulon® Fuel Lock FL-LP (Vibration Welded) Resin Material Fuel Tanks

Minimum barrier thickness (mm)	Nominal overall tank thickness (mm)
1.95	2.30

IT IS FURTHER ORDERED that DSM Engineering Plastics shall provide a warranty to equipment manufacturers purchasing their model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks. The warranty must conform to the requirements of Cal. Code Regs., title 13, section 2760.

IT IS FURTHER ORDERED that the certified model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks shall be installed in accordance with the manufacturer's installation and use instructions for the tanks. A copy of this EO and installation and use instructions for the fuel tanks shall be provided to manufacturers purchasing DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks for installation on small off-road engines and equipment introduced into commerce in California.

IT IS FURTHER ORDERED that DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks shall be clearly identified by a permanent identification that allows ARB to identify the manufacturer's name, EO number, and model number.

IT IS FURTHER ORDERED that any modification of the DSM Engineering Plastics approved process and material specifications for producing model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks is prohibited. Any alteration or modification of the process or material specifications set out in Attachment A of this EO will require the manufacturer to apply for a new EO.

IT IS FURTHER ORDERED that the DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks shall be compatible with fuels in common use in California at the time of certification and any modifications to comply with future California fuel requirements shall be approved in writing by the Executive Officer or Executive Officer's delegate.

IT IS FURTHER ORDERED that the innovative product certification of the DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks can be referenced in certification applications for small off-road engines and equipment that use small off-road engines unless the Executive Officer finds that the DSM Engineering Plastics model Akulon® Fuel Lock FL-LP (Vibration Welded) resin material injection molded fuel tanks no longer meet the performance requirements set forth in Cal. Code Regs., title 13, section 2754, when tested pursuant to Cal. Code Regs., title 13, section 2765.

Executed at Sacramento, California, this 16th day of April 2013.

Dr. Michael T. Benjamin, Chief
Monitoring and Laboratory Division

Injection Molding Conditions for *Akulon® Fuel Lock FL-LP*

Material Handling

In order to prevent moisture pick up and contamination, supplied packaging should be kept closed and undamaged. For the same reason, partial bags should be sealed before re-storage. All the material that has been stored elsewhere to adapt to the temperature in the processing room while keeping the bag closed.

Packaging

Akulon® Fuel Lock FL-LP is supplied in airtight, moisture-proof packaging.

Moisture Content as Delivered

Akulon® Fuel Lock FL-LP is packaged at a moisture content level of ≤ 0.15 wt%.

Moisture Content before Molding

Since *Akulon® Fuel Lock FL-LP* is delivered at molding moisture specification (≤ 0.15 wt%), the resin can be molded without pre-drying. However, to overcome the fluctuation from package to package, we advise to pre-dry (see drying section below). Furthermore, pre-drying is required in case the material is exposed to moisture before molding (package damage or previous opened for longer periods of time). Moisture content can be checked by water evaporation methods or manometric methods (ISO 15512).

Drying

Akulon® Fuel Lock FL-LP is hygroscopic and absorbs moisture from the air relatively quickly. Preferred dryers are dehumidified dryers with dew points maintained between -30°C and -40°C (-22°F and -40°F). Vacuum driers with N_2 purge may also be used. Hot air ovens or hopper driers are not suitable for pre-drying Akulon® Fuel Lock FL-LP; the use of such driers may result in non-optimum performance.

Akulon® Fuel Lock FL-LP Drying Temperatures

Moisture Content (wt%)	Drying Time (hrs)	Drying Temperature (°C / °F)
0.1 to 0.2 (and as delivered)	2 to 4	80 / 176
0.2 to 0.5	4 to 8	80 / 176

Injection Molding Conditions for *Akulon® Fuel Lock FL-LP*

Regrind

Regrind may be used, providing that this material is kept clean, dry, with low dust content, not previously thermally degraded, uncontaminated with other polymers and in similar particle size to the original material. The acceptable level of first generation regrind may be as high as 100%, providing the above conditions are met. Parts made from this material are expected to result in fuel tanks that exhibit essentially the same physical, mechanical and fuel permeation properties of the virgin *Akulon® Fuel Lock FL-LP* product. Reground material, however, can result in slight color variations from the virgin material, primarily in the natural color.

Injection Molding Machinery

Akulon® Fuel Lock FL-LP can be processed on general injection molding machines.

Screw Geometry

Typically, three zone screw designs with volumetric compression ratios of approximately 2.5:1 are optimal.

Steel Types

Abrasion resistant tool steels are recommended for use in tools, nozzles, screws and barrels for molding *Akulon® Fuel Lock FL-LP*.

Temperature Control

The use of an open nozzle with good temperature control and an independently controlled thermocouple near the tip is recommended. Heater bands capable of achieving the recommended processing temperature profile are necessary.

Mold Temperatures

Akulon® Fuel Lock FL-LP can be successfully molded using a broad range of mold temperatures – from 50°C (122°F) to 80°C (176°F). We recommend using the lower end of the mold temperature range to reduce sticking and for tanks with thicker wall sections (>2.5mm or 0.100"). Molding parts in *Akulon® Fuel Lock FL-LP* at the higher end of the mold temperature range will improve dimensional stability, flow properties and surface appearance.

Injection Molding Conditions for *Akulon® Fuel Lock FL-LP*

Barrel Temperatures

Optimal temperature settings are governed by barrel size, residence time and melt viscosity. Due to the relatively high melting point of *Akulon® Fuel Lock FL-LP* this temperature should be set high enough to achieve a homogeneous melt without approaching the degradation temperatures, which begin at 300°C (572°F). A flat or rising temperature profile is recommended.

Melt Temperature

To generate a homogeneous polymer melt, this temperature should always be above 240°C (464°F). Optimal mechanical properties will be achieved at melt temperatures between 240-275°C (464-527°F). We advise to frequently measure the melt temperature using a thermocouple probe inserted into the melt.

Hot Runner Temperatures

Hot runner temperatures set to the same level as the nozzle temperature is recommended and should not result in overheating of *Akulon® Fuel Lock FL-LP*. When starting up, an increased tip temperature may be necessary to overcome a frozen nozzle.

Akulon® Fuel Lock FL-LP Injection Molding Temperatures

	Mold	Melt	Nozzle	Front	Center	Rear
°C	50 - 80	240 - 275	240 - 260	240 - 250	235 - 250	230 - 235
°F	122 - 176	464 - 527	464 - 518	464 - 500	455 - 482	446 - 455

Screw Rotation Speed

To realize a good and homogeneous melt, it is advised to set the screw rotation speed resulting in a plasticizing time that is just within the cooling time. The rotation speed of the screw should not exceed 6500 / D, where D is the screw diameter in mm.

Injection Molding Conditions for *Akulon® Fuel Lock FL-LP*

Back Pressure
Back pressure should be between 30 – 100 bar (435 – 1,450 psi) effective. Keep the back pressure as low as possible to avoid nozzle drooling, excessive shear heating and long plasticizing times.

Decompression
In order to prevent nozzle drool after plasticizing and retraction of the nozzle from the mold, a short decompression stroke can be used. However, to prevent oxidation of the melt, which may result in surface defects on the parts, it is recommended to keep this as short as possible.

Injection Speed
Moderate to high injection speeds are required in order to prevent premature crystallization in the mold during the injection phase and to obtain a better surface finish. Adequate mold venting is required to avoid burning at the end of the flow path.

Injection Pressure
The set injection pressure should be high enough to maintain the set injection speed (use set injection pressure higher than the peak pressure if possible). Tooling air vents must be effective to allow optimum filling pressure and prevent burn marks.

Holding Time
Effective holding time is determined by part thickness and gate size. Holding time should be maintained until a constant product weight is achieved.

Holding Pressure
Adequate holding pressure is where no sink marks or flash on the part are visible. Using too high a holding pressure may lead to stresses within the part.

Cooling Time
Actual cooling time will depend upon the part geometry and dimensional quality requirements, as well as the tool design (gate size).

Injection Molding Conditions for *Akulon® Fuel Lock FL-LP*

Residence Time

Melt residence time for *Akulon® Fuel Lock FL-LP* in general, should not exceed six (6) minutes with preferably at least 50% of the maximum shot volume used. Optimal melt residence time should be < four (4) minutes.

Safety

For the safety properties of *Akulon® Fuel Lock FL-LP* please refer to the Material Safety Data Sheet, available from DSM Engineering Plastics.

Start Up / Shut Down / Cleaning

Production of *Akulon® Fuel Lock FL-LP* must be started and ended with a clean molding machine. Cleaning may be done with the material itself, applicable cleaning agents or HDPE.

Production Breaks

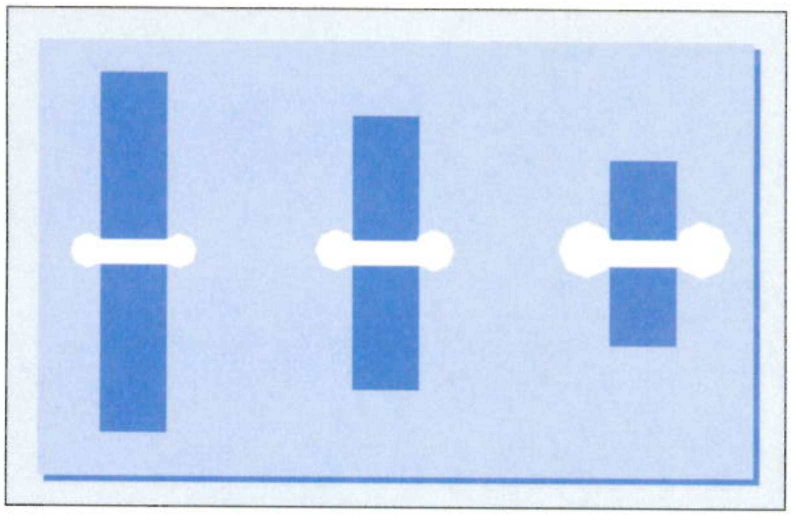
During breaks in production of *Akulon® Fuel Lock FL-LP* for more than a few minutes, we advise emptying the barrel of material, and reducing the barrel temperature to a level far enough below the melt point in order to prevent decomposition. When the hot runner, nozzle or the screw is blocked, be aware that under these conditions a sudden outburst of molten material may take place. Always wear personal safety protection for hand/eye/body.

Vibration Welding Processing Instructions
Akulon® Fuel Lock FL-LP

Akulon® Fuel Lock FL-LP may be successfully processed into small engine fuel tanks that meet the pertinent physical and mechanical requirements of this application. This grade of Fuel Lock has been developed for use in the injection molding process, whereby tank halves are injection molded and subsequently joined together using the vibration welding process.

In vibration welding, the plastics parts to be joined are vibrated (rubbed) against each other at a chosen frequency, amplitude and pressure. This relative motion results in the frictional heating of the surfaces, causing the polymer to melt at the interface. The molten polymer flows out of the weld-zone giving rise to flash, see figure 62.

Figure 62 Schematic representation of the welding process.

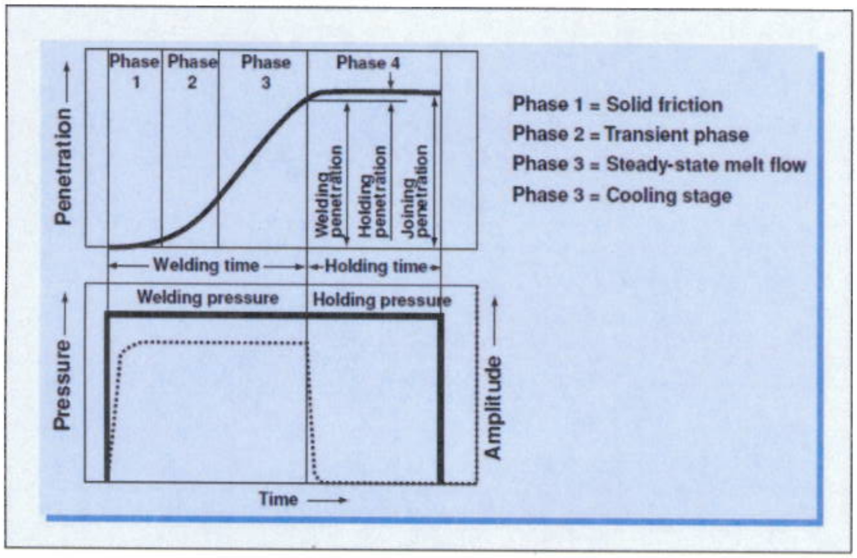


When the vibration ceases, the weld cools down and solidifies. Vibration welding is a cost-effective process, with short cycle times. Vibration welding has the advantage that the polymer melt is not exposed to open air, which can be important for materials that are susceptible to thermo-oxidative degradation.

Four phases can be distinguished in the vibration welding process, namely the solid friction phase, transient phase, steady-state phase and cooling phase, see figure 63.

Vibration Welding Processing Instructions
Akulon® Fuel Lock FL-LP

Figure 63 The phases of the vibration welding process.



In the solid friction phase, the heat generated due to frictional energy between the two surfaces (frequency of vibration, amplitude, and pressure) causes the material to heat up and melt.
In the second phase the molten polymer layer increases due to shear heating in the viscous (melt) phase. Heating decreases as the thickness of the viscous layer increases. In the third phase, the rate at which melt is formed becomes equal to the outward flow rate (film drainage) and this comes to a steady state (the thickness of the molten layer becomes constant). Vibrations are stopped at this point. The polymer melt starts to cool, the cooling phase, and solidification results at the interface of the joint. Film drainage will continue while the joint is held under pressure. When solidification is complete the pressure is withdrawn and the joint is formed.

Vibration Welding Processing Instructions
Akulon® Fuel Lock FL-LP

Typical vibration welding process parameters are:
- Frequency: 100-400 Hz
- Amplitude: 0.5-2.5 mm (0.02-0.10 in)
- Cycle time: 10 seconds
- Weld pressure: 0.5-5 MPa (70-700 psi)

During welding a special fixture is required to hold the components. The mating surfaces must be parallel. Three-dimensional contours are not possible due to the vibratory motion. If visible flash is not acceptable, the joint can be provided with flash traps, as seen in figure 66, part C.

Figure 66 Typical joint designs for vibration welding.